Listing of Claims

The following listing of claims will replace all prior versions, and listings, of claims in the subject application:

1. (original) A method of performing an automatic and rapid auditory screening test on a patient, the method comprising:

a. acoustically presenting at least one modulated noise stimulus at a specific intensity to at least one ear of the patient;

b. recording response data related to the patient's response to the at least one stimulus;

c. performing signal analysis on said response data to generate result data;

d. evaluating the result data using at least one statistical technique to determine the presence of at least one auditory steady-state response; and,

e. providing a pass/fail test result which indicates whether said patient has passed or failed said screening test.

2. (original) The method of claim 1, wherein the at least one modulated noise stimulus includes at least one of: amplitude modulated broadband noise (BBN), amplitude modulated band-pass noise, amplitude modulated high-pass noise (HPN), and enhanced high-pass noise (EHPN).

3. (currently amended) The method of ~~any one of claims 1 and 2~~ claim 1, wherein for step (d) the statistical technique includes generating a significance series by sequentially analyzing combined portions of the response data to generate a significance series of probability values

for the at least one auditory steady-state response, and subjecting the significance series to a statistical conditional criteria to determine the presence of the response.

4. (original) The method of claim 3, wherein said subjecting to a statistical conditional criteria includes using at least one of: an absolute count, a consecutive count, a relative count and a Bonferroni adjusted critical value.

5. (currently amended) The method of ~~any one of claims 3 and 4~~ claim 3, wherein the probability values of said significance series are compared to a critical value of at least one of: a 0.05 value, a 0.01 value, a constant value, a changing value, and a Bonferroni adjusted critical value

6. (original) The method of claim 1 in which step (c) comprises using weighted averaging in said signal analysis.

7. (original) The method claim 1 in which step (c) includes:

(i) forming a plurality of epochs of response data using said response data;

(ii) forming a plurality of sweeps of the response data by concatenating the plurality of epochs of response data;

(iii) classifying each epoch of response data selected from the plurality of epochs of data as a rejected epoch if the epoch of data fails to meet one or more of the following criteria: having an SNR level above a specified value for at least one specified frequency bin of an amplitude spectrum of the epoch of data; and having an

inadequate value for passing a homogeneity criteria;

(iv) forming a plurality of accepted sweeps of the response data by concatenating the plurality of non-rejected epochs of data; and

(v) converting the accepted sweeps into the frequency domain to generate said result data

8. (original) The method of claim 7, wherein the homogeneity criteria include at least one of the following: intra-sweep homogeneity criteria which are adjusted based upon statistical evaluation of at least one characteristic that is measured for each epoch of data within each sweep, and intra-sweep homogeneity criteria which are adjusted based upon at least one characteristic that is measured for each epoch of data within two or more sweeps.

9. (original) The method of claim 8, wherein the at least one characteristic that is measured for each epoch of data is at least one of the following: an estimate for EEG-noise energy, an estimate of signal energy, and an SNR estimate.

10. (original) The method of claim 1, wherein a hearing threshold of the a patient is obtained for at least one steady-state stimulus by iteratively performing steps a-d a number of times using different stimulus intensities, and during each iteration generating a significance series wherein for each different stimulus intensity, said auditory steady-state response is determined to be statistically present when selected statistical conditional criteria are met, and the lowest intensity for which a steady-state response is determined to be statistically present is the hearing threshold for said steady-state stimulus.

11. (original) A method of performing an automatic and rapid hearing threshold test on a patient, the method comprising:

a. acoustically presenting at least one transient stimulus at a rapid periodic rate to at least one ear of the patient;

b. recording response data related to the patient's response to the at least one transient stimulus, wherein several epochs of response data are recorded and the at least one transient stimulus is presented at a periodic rate that provides an inter-stimulus interval that is a sub-multiple of an epoch length;

c. performing signal analysis on said response data to generate result data;

d. evaluating the result data using at least one statistical technique to determine the presence of at least one auditory response, wherein said evaluating comprises evaluating the result data using a statistical technique to determine the presence of at least one auditory steady-state response, said statistical technique comprising a significance series and statistical conditional criteria of at least one of an absolute count, a consecutive count, and a relative count; and

e. providing a pass/fail test result which indicates whether said patient has passed or failed a threshold hearing test.

12. (original) A method of testing auditory function of a patient, the method comprising:

a. acoustically presenting at least one ramp stimulus to at least one ear of the patient;

b. recording response data epochs of ramping evoked response data related to the patient's response to said at least one ramp stimulus;

c. classifying said response data epochs into accepted response data epochs and rejected response data epochs, said response data epoch being classified as rejected response data epochs if said response data epoch fails in meeting a homogeneity criteria;

d. performing signal analysis and time-frequency analysis on said accepted response data to generate result data; and,

e. using the result data to compute the subject's threshold for said at least one ramp stimulus.

13. (original) The method of claim 12, further comprising substituting said rejected response data epochs with new epochs using at least one of: a zero replacement technique, a swapping replacement technique, wherein said new epochs are classified as accepted response data epochs.

14. (original) The method of claim 13, wherein the zero replacement technique comprises substituting values of rejected epoch with zeros, and also comprises reducing the total number of sweeps by one when computing an average sweep from a sum of sweeps.

15. (original) The method of claim 13, wherein the swapping replacement technique comprises replacing epochs of data epochs from a different sweep which is synchronized in a similar fashion to the stimulus.

16. (original) The method of claim 12, wherein at least one base signal which is used to create the at least one ramp stimulus is at least one of: a periodic transient stimulus, a

periodically modulated tone, and a periodically modulated noise stimulus.

17. (original) The method of claim 16, wherein the base signal is the periodic transient stimulus, and the periodic transient stimulus is presented at a repetition rate that provides an inter-stimulus interval which is an integer sub-multiple of the length of one of the response data epochs.

18. (original) The method of claim 17, wherein performing signal analysis includes the steps of:

I. computing a spectrogram by shifting a data window across an averaged sweep generated from said accepted response data epochs;

II. obtaining phase values from the spectrogram for R-AEPs for at least one ramp stimulus; and

III. obtaining a phase plot from said phase values using the relationship:

$$\theta_a = \theta_c ((T_c / L) * 360$$

where θ_a is an actual phase value of a response frequency being measured, θ_c is a un-corrected phase value of a response frequency being measured in each data window used to generate a spectrogram, T_c is a cumulative time for a total number of points that have occurred in the response data prior to the first point of each data window, and L is a stimulus period of the at least one ramping stimulus.

19. (original) The method of claim 12, wherein the at least one ramp stimulus is created using a ramp function that is at least one of the following: a linear ramp, a logarithmic ramp,

a multi-slope ramp, and a symmetrical ramp having an upward and downward ramp, the intensity at the end of the upward ramp being substantially similar to the intensity at the beginning of the downward ramp, and with the upward and downward ramps being selected from one of a linear ramp, a logarithmic ramp, and a multi-slope ramp.

20. (original) A method for performing a Multiple Intensity Stimulus Test for rapidly evaluating auditory function of a patient comprising:

a. acoustically presenting at least two periodic acoustic stimuli of different intensities to at least one ear of a subject;
b. recording steady-state response data related to the patient's response to the at lest two periodic acoustic stimuli;
c. performing signal analysis on said response data to generate result data, and
d. using the result data to statistically evaluate the presence of steady-state response to at least said at least two periodic acoustic stimuli; and
e. providing at least one of the following: a pass/fail result for a screening test and an estimate of the patient's hearing threshold.

21. (original) A system for performing an automatic and rapid screening test on a patient, the system comprising:

a. means for acoustically presenting at least one modulated noise stimulus to at least one ear of the patient,
b. means for recording steady-state response data related to the patient's response to said at least one modulated noise stimulus;

c. means for performing signal analysis on said steady-state response data to generate frequency domain result data;

d. means for statistically evaluating the frequency domain result data to determine the presence of at least one auditory steady-state response; and,

e. means for providing a pass/fail result which indicates whether said subject has passed or failed said screening test.

22. (original) A method of testing auditory function of a patient, the method comprising:

a. acoustically presenting at least one ramp stimulus having a selected intensity range to at least one ear of the patient;

b. recording response data epochs of ramping evoked potential response data related to the patient's response to said at least one ramp stimulus;

c. classifying said response data epochs into accepted response data epochs and rejected response data epochs, wherein a response data epochs is classified as rejected if said response data epoch fails in meeting a homogeneity criteria;

d. performing time-frequency signal analysis on the acceptable response data epochs to generate result data, and

e. using said result data to compute an estimate of said patient's threshold for at least said one ramp stimulus.

23. (original) The method of claim 22, further comprising performing steps (a)-(e) iteratively, and for each iteration, including an estimate of said patient's threshold in a threshold series, wherein the iterations are continued until said threshold series meets a

statistical conditional criteria related to a reliability measure of the threshold estimate.

24. (original) The method of claim 22, further comprising performing steps (a)-(e) iteratively, and on each iteration, including an estimate of said patient's threshold for two or more ramp stimuli in two or more threshold series, wherein the iterations are continued until said two or more threshold series meet statistical conditional criteria related to a reliability measure of the threshold estimate.

25. (currently amended) The method of ~~any one of claims 12 and 22~~ claim 12, wherein the result data include at least one of the following: estimates of instantaneous amplitudes and phases of R-AEPs at different moments in time, estimates of instantaneous amplitudes of EEG-noise level estimates at different moments in time, an average of estimates of instantaneous amplitudes of EEG-noise level estimates at different moments in time, estimates of instantaneous statistical probability that R-AEPs are present at different moments in time, and a spectrogram.

26. (original) The method of claim 22, wherein the homogeneity criteria include at least one of the following: intra-sweep homogeneity criteria which are adjusted based upon statistical evaluation of at least one characteristic that is measured for each epoch of data within a sweep, intra-sweep homogeneity criteria which are adjusted based upon at least one characteristic that is measured for an epoch of data within two or more sweeps, and intra-column homogeneity criteria which are adjusted based upon at least one characteristic that is measured for an epoch of data, that is organized within a same column of epochs, said

column of epochs containing all accepted epochs that are time locked to a particular portion of a ramp stimulus.

27. (original) The method of claim 26, wherein the at least one characteristic that is measured for an epoch of data is at least one of the following: an estimate for EEG-noise energy, an estimate of signal energy, and an SNR estimate.

28. (original) The method of claim 22, wherein rejected epochs are replaced using at least one of a zero replacement technique, a swapping replacement technique, and a repeating replacement technique.

29. (currently amended) The method of ~~any one of claims 12 and 22~~ claim 12, wherein a method to compute an estimate of said patient's threshold for at least said one ramp stimulus is chosen from one of the following: the lowest intensity for which R-AEP amplitudes are not statistically present, the lowest intensity for which the R-AEP phases are not statistically stable, regression techniques, regression techniques applied only to R-AEP amplitudes which are statistically present, and regression techniques applied only to R-AEP amplitudes which occur over a limited time period or intensity range of the stimulus.

30. (original) The method of claim 12, wherein the at least one ramp stimulus is created using a ramp function that is at least one of the following: a linear ramp, a logarithmic ramp, a multi-slope ramp, and a symmetrical ramp having an upward and downward ramp, the intensity at the end of the upward ramp being substantially similar to the intensity at the

beginning of the downward ramp with the upward and downward ramps being selected from one of a linear ramp, a logarithmic ramp, and a multi-slope ramp.

31. (currently amended) The method of claim 22, further comprising:

~~a~~ f. partitioning a stimulus intensity range into several intensity ranges, the number of intensity ranges corresponding to the number of ramp stimuli, and uniquely assigning one of the intensity ranges to each of the ramp stimuli;

~~b~~ g. performing steps a-e iteratively to generate a threshold series for each of the ramp stimuli based on iterative estimates of the patient's threshold and continuing the iterations until the threshold series meets specified criteria; and,

~~a~~ h. using at least one of the threshold series to provide an overall threshold estimate for the patient.

32. (original) The method of claim 31, wherein the several intensity ranges are non-overlapping.

33. (original) The method of claim 31, wherein the overall threshold estimate is generated by combining the threshold estimate for each of the ramp stimuli.

34. (new) The method of claim 25, further comprising:

f. partitioning a stimulus intensity range into several intensity ranges, the number of intensity ranges being equal to the number of ramp stimuli and uniquely assigning one of the intensity ranges to each of the ramp stimuli;

g. performing steps a-e iteratively to generate a threshold series for each of the ramp stimuli based on iterative estimates of the patient's threshold and continuing the iterations until the threshold series meets a specified criteria; and,

h. using at least one of the threshold series to provide an overall threshold estimate for the patient.

35. (new) The method of claim 25, wherein the several intensity ranges are non-overlapping.

36. (new) The method of claim 25, wherein the overall threshold estimate is generated by combining the threshold estimate for each of the ramp stimuli.

37. (currently amended) The method of claim 22, wherein the method further comprises:

~~a~~ f. selecting a second intensity range for a ramp stimulus based on an estimate of the patient's threshold, the second intensity range being selected to straddle the estimate of the patient's threshold and the second intensity range being smaller than the intensity range selected in step (a); ~~and~~

~~b~~ g. performing steps a-e based on the intensity range selected in step (f)~~.~~ ;

~~38. The method of claim 37, wherein the method further comprises:~~

~~a~~ h. using the signal to noise levels of the result data to determine a useful intensity range for a second ramp stimulus;

~~b~~ i. replacing said ramp stimulus with said second ramp stimulus; and,

~~c~~ j. performing steps a-e iteratively to generate a threshold series for the second ramp stimulus based on iterative estimates of the patient's threshold and continuing the

iterations until the threshold series meets a specified criteria.

38. (original) The method of claim 37, wherein the intensity range of the second ramp stimulus is chosen to be closer to the intensity range of the ramp stimulus in step (a) if the signal to noise level is low and the intensity range of the second ramp stimulus is chosen to be further away from the intensity range of the ramp stimulus in step (a) if the signal to noise level is high.

39. (currently amended) The method of claim 2, wherein the method further comprises:

~~a~~ f. using signal to noise levels of the result data to determine a useful intensity range for a second ramp stimulus;

~~b~~ g. rejecting the accepted response data epochs which do not correspond to the intensity range of the second ramp stimulus, and reorganizing the remaining response data epochs so that they correspond to the data collected with the second ramp stimulus; and

~~a~~ h. performing steps a-e iteratively with said second ramp stimulus to generate a threshold series based on iterative estimates of the patient's threshold and continuing the iterations until the threshold series meets a specified criteria.

40. (original) A method of testing auditory thresholds according to a Conditional MASTER Screening Test, the method comprising:

a. presenting at least three acoustic stimuli to at least one ear of a patient;

b. recording SS-AEP data epochs related to the patient's response to the at least three acoustic stimuli;

c. classifying said SS-EP data epochs into accepted epochs and rejected epochs on the basis of selected criteria;

d. processing the accepted epochs to determine which SS-AEPs are statistically present

e. repeating steps a-d until a specified criteria have been met; and

f. providing a pass result if at least a specified number of SS-AEPs were statistically present and a fail result if less than a specified number of SS-AEPs were not statistically present.

41. (original) The method of claim 40, wherein in step d, wherein an SS-AEP is determined to be statistically present when a significance series has been generated for each SS-AEP and the statistical series has successfully met one or more statistical conditional criteria.

42. (original) The method of claim 40, wherein the specified criteria of step e, is at least one of: an amount of recording time and a level of background EEG-noise present in the recording.

43. (original) The method of claim 40, wherein said classifying of SS-AEP data in step "c" is based upon failure or success of said SS-AEP data epoch in meeting homogeneity criteria.

44. (original) A method of optimizing modulation frequencies used in an audiometric test that provides at least one modulated stimulus to evaluate the auditory system of a patient, the

method comprising:

a. performing a modulation optimization test (MOT) to produce result data;

b. analyzing the result data to derive at least one modulation rate with SNR characteristics meeting selected criteria; and,

c. using the at least one modulation rate in an objective auditory test on the patient.

45. (original) The method of claim 44, wherein the objective auditory test comprises at least one of an ASSR test, a MASTER test, and RAMPER test.

46. (original) The method of claim 44, wherein step (a) comprises:

(i) presenting at least one stimulus to the patient, said stimulus having a modulation rate which changes over time;

(ii) recording evoked response data related to the patient's response to the at least one stimulus; and

(iii) analyzing the evoked response data to produce result data, said result data containing the SNR characteristic for at least 2 modulation frequencies.

47. (original) The method of claim 46, wherein in step (iii) analyzing the evoked response data is accomplished using time frequency analysis.

48. (original) The method of claim 46, wherein step (i) includes presenting the at least one stimulus to the patient at an intensity level that is at least 10 dB above the stimulus intensities for use in a subsequent audiometric test.

49. (original) The method of claim 46, wherein step (i) includes presenting RAMP stimuli to at least one of the left and right ears of the patient.

50. (original) The method of claim 49, wherein the at least a stimulus is presented to each of the patient's ears and the stimuli are selected from the group of same stimuli to each ear and stimuli presented to the left ear that differ from those presented to the right ear.

51. (original) A method of performing a R-AEP Fine Structure Test to evaluate auditory system of a patient comprising:

a. presenting at least one acoustic ramp stimulus to the patient;
b. recording evoked response data from the patient to form primary data;
c. performing signal analysis on the primary data, and rejecting primary data sections which do not meet specified homogeneity criteria, to obtain processed data;
d. analyzing the processed data using time-frequency analysis to produce result data;
e. using the result data to evaluate auditory capacities of the auditory system of said patient.

52. (original) The method of claim 51wherein the at least one acoustic ramp stimulus has a modulation rate that is ramped over time whereby the test comprises a modulation optimization test.

53. (original) The method of claim 51, wherein the at least one acoustic ramp stimulus has a

carrier frequency that is ramped over time whereby the test comprises a Fine-Structure Test.

54. (original) The method of claim 51, wherein the at least one acoustic stimulus comprises a masking stimulus that is selected from the group of modulated and unmodulated masking stimuli and has a carrier signal frequency that varies over time, and a probe stimulus having a constant carrier signal frequency and a constant modulation rate, whereby the test comprises a RAMPER Masking Test.

55. (new) The method of claim 22, wherein the result data include at least one of the following: estimates of instantaneous amplitudes and phases of R-AEPs at different moments in time, estimates of instantaneous amplitudes of EEG-noise level estimates at different moments in time, an average of estimates of instantaneous amplitudes of EEG-noise level estimates at different moments in time, estimates of instantaneous statistical probability that R-AEPs are present at different moments in time, and a spectrogram.

56. (new) The method of claim 22, wherein a method to compute an estimate of said patient's threshold for at least said one ramp stimulus is chosen from one of the following: the lowest intensity for which R-AEP amplitudes are not statistically present, the lowest intensity for which the R-AEP phases are not statistically stable, regression techniques, regression techniques applied only to R-AEP amplitudes which are statistically present, and regression techniques applied only to R-AEP amplitudes which occur over a limited time period or intensity range of the stimulus.